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ABSTRACT

Although adult numeracy or basic mathematics classes have existed throughout Australia since at least the 1970s, they did not receive prominence in provision or policy until the endorsement of the Australian Language and Literacy Policy in 1991. The following are still lacking, however: expectation that adult numeracy teachers will have formal specific qualifications; systematic exploration of the nature of numeracy and development or nationally agreed-upon definitions; clear policy statements about the significance of numeracy in Australian society and strategies to address perceived needs for training and development; data on the extent of the need for national-level provision in adult literacy; and funding for designated research projects in adult numeracy. Further research is also needed on the following topics: nature of adult numeracy; role of language in numeracy and mathematics; role of mathematics in language; needs of specific groups in numeracy education; adult numeracy practices and needs; critical numeracy; adult learning and numeracy; effective instruction, assessment, and reporting in adult numeracy; and policy initiatives and provision effects in adult numeracy provision. Research initiatives in policy, provision, and pedagogy should be initiated immediately. (Contains 19 references.) (MN)

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Adult Numeracy

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ADULT NUMERACY POLICY AND RESEARCH IN AUSTRALIA:

THE PRESENT CONTEXT AND FUTURE DIRECTIONS

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prepared for the National Research Strategy in Adult Language, Literacy and Numeracy Project, December 1995

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Foreword

In 1995 the Integrated Research Strategy Project (which included numeracy within its definition of language and literacy) was an Australian Language and Literacy Policy project commissioned by the then Department of Employment, Education and Training to support initiatives for the implementation of the National Collaborative Adult English Language and Literacy Strategy. Its aim was to provide a clear picture of the existing state of research in the field of adult English language and literacy and to provide guidelines for future directions.

This paper arose out of the perception of the central importance of numeracy. It comes at a time when there is growing concern about numeracy in the community of language and literacy professionals and there is a clear need for a guide to assist teachers and researchers who are beginning to explore numeracy in their professional activities.

I hope this guide serves as a catalyst for facilitating more research in the field of numeracy.

Rosa McKenna

Integrated Research Strategy
Project

THE PRESENT CONTEXT FOR ADULT ENGLISH LANGUAGE, LITERACY AND NUMERACY POLICY AND PROVISION

Adult literacy was recognised as an issue in Australia during International Literacy Year (ILY) in 1990. This recognition was due in no small part to the impact of the first national survey of aspects of adult literacy (Wickert, 1989 "Wickert, 1989") and to the determined lobbying by those who had been involved in adult literacy and numeracy provision, policy and research for many years previously. The continued activities by many of these people, with the added voices of others, have ensured that literacy policy and provision remain on national and state agendas. The most significant aspect of the recognition of literacy was recognition of the needs for provision in literacy for adults for whom English was a first language, not just for second language speakers. Policy and funding for provision in English as a second language were already well-established. By 1995, literacy is no longer the poor cousin. An important change in policy over the last few years has been the strengthened collaboration in policy, provision and research for English as a first and second language. Within this collaboration, to date, both areas appear to be 'holding a voice', to be recognised as having similarities and differences, with policy, provision and research addressing these. Major developments have been the endorsement of the Australian Language and Literacy Policy ("Australian Language and Literacy Policy (1991)" 1991), the formation of the Australian Language and Literacy Council, and the extension of the National Languages Institute of Australia (Ltd) (NLIA) to include literacy (NLLIA).

These policy changes and emphases have been accompanied by, or perhaps accompany, changes in the nature of the workplace over the last decade. Increased technology, award restructuring, multiskilling, enterprise bargaining and competency-based training and assessment have all had an impact on perceptions of the nature of work. Accompanying these perceptions has been identification of the significance of literacy for undertaking work in this environment. The end result of all of these workplace and literacy policy activities has been increased funding for literacy training particularly in vocational contexts, increased attention to basic education courses with the development of national and state accredited curricula, and increased accountability. Competitive funding for designated research studies in adult English language and literacy has continued since International Literacy Year. A National Collaborative Adult English Language and Literacy Strategy ("National Collaborative Adult English Language and Literacy Strategy (1993)" 1993) was developed to 'highlight(s) the importance of English language and literacy skills to individuals and the community ... and

strengthen(s) our governments' commitment to the improvement of these skills across all ages and in all situations ... demonstrating that language and literacy development is a responsibility of the whole society' (p. 1).

THE SITING OF NUMERACY WITHIN THE PRESENT CONTEXT

Prior to International Literacy Year, the terminology commonly used to refer to non-compulsory education in the adult sector was ESL, adult literacy and adult basic education. Adult basic education implicitly included both literacy and numeracy. While adult numeracy or basic mathematics classes have existed throughout Australia since at least the 1970's (Bradshaw & Tout, 1990 "Bradshaw & Tout, 1990"), they have never received prominence in provision or policy, often being regarded as an 'add on'. One of the first nationally accepted definitions of literacy that attempted to broaden the perception of literacy from the development of decoding and spelling skills in reading and writing was that promoted by the Australian Council for Adult Literacy and ILY:

> *Literacy involves the integration of listening, speaking, reading, writing and critical thinking: it incorporates numeracy. ...*

While the definition did not elaborate the concept of numeracy, it did allow for numeracy activities to take place through the auspices of adult literacy policy and funding. The Australian Language and Literacy Policy modified the definition to enunciate the type of numeracy or mathematical operations seen as being incorporated in literacy:

> *Literacy is the ability to read and use written information and to write appropriately, in a range of contexts. ... Literacy also includes the recognition of numbers and basic mathematical signs and symbols within text. ... (Australian Language and Literacy Policy, 1991, p.9)*

This latter definition is consistent with the aspects of literacy assessed through the international studies of adult literacy undertaken in the United States of America, Canada and Australia (*No Single Measure*, Wickert, 1989) and the proposed 1996 Australian Bureau of Statistics *Survey of Aspects of Literacy*. In these surveys, three dimensions of literacy have been assessed: Prose Literacy, Document Literacy and Quantitative Literacy. Quantitative Literacy investigates 'the use of mathematical operations such as addition, subtraction, multiplication and division - either singly or in combination - to solve (numerical) problems that are embedded

in varying degrees in printed material' (Kirsch & Jungeblut, 1986, cited in Wickert, 1989, p.21).

The enactment of numeracy within the policy definitions and the national surveys, therefore, has been to focus mostly on arithmetical operations within text. The realm of numeracy itself has been undefined and unexplored at a national level. The National Collaborative Adult English Language and Literacy Strategy (1993) states that 'it encompasses both adult literacy and adult English as a second language provision' (p.3). The term 'numeracy' is not mentioned throughout the document. It is therefore incumbent upon the reader to identify the term 'literacy' as encompassing numeracy, or to perceive that the Strategy is oriented towards English language for first and second language users. The brevity of the document means that numeracy proponents should not read the focus negatively, however, it is at the very least unfortunate that both the Preamble and Rationale (NCAELLS: 2) appear oriented to written text and oral language:

> The first goal of the ALLP states:
>
> *All Australian residents should develop and maintain a level of spoken and written English which is appropriate for a range of contexts with the support of education and training programs addressing their diverse learning needs.*
>
> *... it is estimated that 1.4 million adult Australians (Approximately 13 per cent of the population) have fundamental English language and literacy difficulties. ... A similar survey in Canada concluded that the reading skills of 16 per cent of their adults ...*

Adult numeracy proponents have been grateful to have been accommodated to date within national policies on literacy and language. Overall, this inclusion has meant that adult numeracy policy, provision and research have not been ignored in toto. The question to be addressed now, however, is whether the current inclusion of numeracy as a component of literacy, sometimes explicitly included in literacy agendas, sometimes implicitly, sometimes omitted, is sufficient for the future.

One way to address this question is to examine retrospectively the present status of numeracy policy, research and provision as an outcome of national and state strategies (in contrast to an outcome due to the commitment of individuals within adult numeracy). In summary the extant status of adult numeracy as an outcome of strategy and policy are the **inclusion** or

Incorporation of numeracy within:

- literacy definitions
- national surveys as quantitative literacy
- the National Framework of Adult Language, Literacy and Numeracy Competence (ACTRAC, 1993 "ACTRAC, 1993")
- the National Reporting System (Coates, Fitzpatrick, McKenna & Makin, 1995 "Coates, Fitzpatrick, McKenna & Makin, 1995")
- national accredited curricula in basic education
- Workplace English Language and Literacy provision guidelines [1]
- some state strategies such as the Queensland Adult English Language, Literacy and Numeracy Strategy.

A nationally accredited Adult Numeracy Teaching Professional Development Course (Johnston & Tout, 1995) has been finalised to replace the minor component on numeracy previously included in the Adult Literacy Teaching Professional Development Course. While policy requires English as a second language teachers to have formal qualifications in the area, and there is a growing requirement for adult literacy teachers to be similarly qualified, there is, as yet, no expectation that adult numeracy teachers will have formal specific qualifications.

The outcomes to date indicate that adult numeracy has emerged reasonably strongly from national agendas. However, it is difficult to determine how many of these outcomes would have eventuated without the persistence and zeal of a core of determined numeracy advocates.

Examination of the outcome in comparison with English language and literacy (excluding numeracy) [2] outcomes from the same strategies and policies indicates a number of major discrepancies that need to be addressed in the future. To date, there

- has been no systematic exploration of the nature of numeracy and development of nationally agreed definitions
- are no clear policy statements about the significance of numeracy in

Australian society and strategies to address perceived needs for training and development

- are no data on the extent of need for provision in adult numeracy at a national level (as opposed to quantitative literacy)

- is no provision of funding for designated research projects in adult numeracy.

Those familiar with the National Collaborative Adult English Language and Literacy Strategy will recognise that these outcomes are among those specified as Objectives and Strategies for English Language and Literacy in Australia. It is in fact possible to take each of the overall focuses of the National Strategy, as well as the specific Objectives and Strategies, and to substitute *Adult Numeracy* for *Adult English Language and Literacy* wherever these words occur. Doing this and rereading the strategy, demonstrate that the above lack of clear policy and direction indicates that the fundamental bases for future directions for adult numeracy policy, research and provision are still to be addressed. There are very few Objectives and Strategies for which distinctive information on adult numeracy can be provided. Furthermore, the nature of numeracy itself is generally not discussed and defined within the above inclusions and incorporations of numeracy.

In response to this statement, I am sure that many will raise two arguments. Firstly, many will see that the definition of literacy that encompasses numeracy will ensure that numeracy is always on the agenda and the numeracy is receiving equivalent strategic focus and funding. The second argument that many will raise is that literacy and numeracy are intertwined and cannot be separated, and that the best adult basic education provision today in both first and second language sectors, integrates both literacy and numeracy. To address both these arguments we need to examine first of all the adequacy of the ways in which numeracy is being defined within literacy, and secondly the ways in which numeracy is conjoint with literacy and separate in identity.

Before examining these issues however, it is worth reinforcing the point that to date there has been very little research funded under the Australian Language and Literacy Policy that has specifically addressed adult numeracy. Notable exceptions include *Breaking the maths barrier* (Marr & Helme, 1992) and the study of *Pedagogical relationships between adult literacy and numeracy* (Lee, Chapman & Roe, 1993). The limits of this research funding indicates an implicit expectation that the needs of adult numeracy research

can be addressed through the definition of numeracy incorporated in literacy, or that numeracy as an issue is not significant.

NUMERACY IN RELATION TO ENGLISH LANGUAGE AND LITERACY

English language and literacy are examined and theorised from many different perspectives. For example, language is examined by linguists from descriptive linguistics and systemic linguistics who consider the structure of language in use and in isolation.[3] Education in first language in the compulsory schooling years has undergone dramatic changes from a primary focus on grammar, spelling, parsing and the interpretation of the 'classics' to whole language approaches, process writing, genre and the critical interpretation of a range of texts. Instruction in English as a second language is not without debates also, with a primary tension still existing between structural (syntax based approaches) and communicative competence approaches. Literacy is a term no longer associated with an age group (adults) but has become used for language instruction across the whole continuum of education. A thoughtful examination of literacy and contending literacy theories, undertaken by Freebody and Luke (1990), identified four components of performance related to reader roles as text: decoders, participants, users and analysts. Freebody and Luke indicate that each of these components is essential for fluent 'reading' while none on its own is sufficient. This amplification of literacy not only accommodates different theories of learning and instruction in literacy, it strongly identifies the components of language use in different contexts and critical awareness of the ways in which language can be used.

This has been a very brief synopsis of the different constructs underlying language and literacy and their change in focus over years. Each of these different constructs has a well-developed and respected research base. Researchers are often identified by their theoretical orientation. At this point, I wonder how comfortable language and literacy researchers and practitioners would feel about identifying different theoretical orientations, constructions and research bases for numeracy and mathematics? For the point of this brief synopsis of change is to provide a framework for considering how numeracy has also evolved. Numeracy is equally complex, equally challenged and challenging. It is not a single concept that can be incorporated within literacy.

THE EVOLUTION AND CONSTRUCTION OF NUMERACY

Numeracy, paralleling early notions of literacy, was for a long time interpreted as back-to-basics arithmetic and computational work. While exemplary adult numeracy practice exists, in much practice today it is still seen as arithmetic and basic 'mathematics', strongly guided by school mathematics curriculum. There can often be an underlying assumption that adult numeracy students are adults lagging in mathematical development whose goal is to progress through the defined stages of the school curriculum.

Yet the term numeracy is first traced to a report by Crowther ("Crowther, 1959" 1959):

> *the ability to deploy mathematical and other skills in tackling(,) systematically (,) problems of concern in every day life and in better understanding the physical, economic and social environment in which we live. (Punctuation inserted to assist interpretation)*

This definition, although nearly 40 years old, is equivalent to today's conceptions of literacy, incorporating various aspects of mathematics in work and everyday life and the notion of numeracy as mathematics in use. The Cockcroft Report (1982), looking at school mathematics in Britain and the problems of developing good mathematical practice, similarly defined numeracy:

> *An at-homeness with numbers and an ability to make use of mathematical skills which enable an individual to cope with practical mathematical demands of his (sic) everyday life ... an ability to have some appreciation and understanding of information which is presented in mathematical terms ... to be able to appreciate and understand some of the ways that mathematics can be used as a means of communication. (p.11)*

Both definitions incorporate notions of appreciation of mathematics and its uses, foreshadowing constructions of critical awareness of the ways mathematics can be used just as language can be used. Both suggest that numeracy subsumes mathematics, envisaging mathematics as a body of knowledge or reasoning systems used for 'everyday' problems, just as literacy to some extent subsumes notions of the constructs of language. Both definitions emphasise 'functional' numeracy for work and everyday life. It is important to note that the reports quoted were investigating the practices of mathematics instruction and chose to use broader frames of numeracy or mathematics

in application, through which to examine mathematics education.

By contrast, the study on literacy and numeracy in Victorian schools (McGaw, Long, Morgan, & Rosier, 1988 "McGaw, Long, Morgan, & Rosier, 1988") conceptualised numeracy as computation through test items consisting of simple arithmetic calculations and everyday applications. More complex problem solving tasks were based on school mathematics tasks rather than everyday functional tasks. The study by McGaw et al. considered functional adult numeracy in terms of the children's results and concluded that it was

> *... possible to define a level on the scale on which the item difficulties and the student performances have been located as the level of numeracy skill that minimally competent adults require in Australian society. (p.29)*

In this construction of numeracy, therefore, at least implicitly, adult numeracy has been expressed in relation to children's school-based work and mathematical functioning in society as an extension of school mathematics.

Willis (1990), a prolific writer on mathematical numeracy in Australia, has not only argued that numeracy is mathematics in use in order to function in life and work but also that numeracy is necessary to partake in the power base of our present society, particularly for women. Numeracy requires not only strong number sense but also appreciation of statistical argument and the assumptions underlying mathematical procedure. Thus Willis' definition echoes the notions of fluency of Freebody and Luke, the numerate person is not only a decoder but a critical reader of mathematics in use.

Definitions of numeracy have emerged recently in the adult numeracy context. In the National Reporting System (Coates et al., 1995), numeracy is described as :

> *using mathematics to make sense of the world; to assist in dealing with real situations which arise in workplace, personal and community settings. While it necessarily involves understanding mathematical ideas, notations and techniques, it also involves drawing on knowledge of particular contexts and circumstances in deciding when to use mathematics, choosing the mathematics to use and critically evaluating its use.* (p.6)

The most important extension of this work on previous definitions is the

description of numeracy which not only reflects 'fluency' in the same ways as for literacy, but which also allows a continuum of numerate behaviour. Numeracy is not confined to simplistic functional activities but exists across the spectrum of mathematical contexts, just as literacy and language span a range of contexts and levels of competence. Betty Johnston in her Keynote address to the 1994 VALBEC Conference explored five ways of meaning-making through mathematics: meaning through ritual, meaning through conceptual engagement, meaning through use, meaning through historical and cultural understanding and meaning through critical engagement. She traces her own engagements with mathematics and teaching of mathematics, seeing numeracy as

> *... a critical awareness which builds bridges between mathematics and the real world, with all its diversity. ... So being numerate is being able to situate, interpret, critique, use, and perhaps even create maths in context, taking into account all the mathematical as well as social and human messiness which comes with it. (Yasukawa & Johnston, 1994, cited in Johnston, 1994, 34)*

In summary, then, the history of constructions of numeracy can thus be traced in parallel with the changing constructions of literacy. The next phase is the further amplification of numeracies, just as multiple literacies are conceptualised. Some research has already been undertaken in this direction. First, however, to extend the context for future strategies in adult numeracy research in Australia, a brief discussion of changes in mathematics education itself will be provided.

It was noted earlier that language education has been through a number of changes and orientations this century. So too has mathematics education. Most of those who are reading this paper will have been through the same mathematics education as I did, an education that related closely to Johnston's meaning-making through ritual — where meaning is acquired through rote-learning of atomised content, and (if lucky) through conceptual engagement — where meaning is constructed through problem-solving, process and cognitive dissonance (Johnston, 1994, 32). Very few of us will have related the mathematics we learned in formal education with the mathematics we use in life, or, as Johnston noted, doing so may have resulted in feeling 'guilty', that it was not 'real' maths' (Johnston, 1994, 33).

Such was the basis of mathematics education in the past, for mathematics itself had initially evolved from its original conception as arithmetic and mensuration to the separate and separated mathematical content areas such

as number and trigonometry. While many were successful in learning mathematics and able to proceed to higher mathematical studies, many were not. There is probably no other area of formal education that has developed such strong negative emotions in so many students. A major reason for these emotions was the emphasis in the past on mathematics as a series of logical steps: steps that occurred in only one correct sequence, drawing on a predetermined set of mathematical facts or algorithms, and that resulted in the production of a unique, correct answer. The emphasis was very much on rote and algorithmic learning.

Mathematics education in formal schooling today is endeavouring to change this perception of successful mathematics performance. The goal of mathematics education is to develop mathematical users and problem solvers. This is perhaps best summarised in statements taken from a 1995 publication by the National Council of Teachers of Mathematics in the United States of America:

> *A shift in the vision of learning mathematics towards investigating, formulating, representing, reasoning, and applying a variety of strategies to the solution of problems — then reflecting on these uses of mathematics — and aware from being shown or told, memorizing, and repeating. This represents a shift from mechanical to cognitive work and also assumes the acquisition of a healthy disposition toward mathematics. Furthermore, cognitive work for all students is culturally dependent because students bring to each lesson their past experiences and the diverse facets of their cultural identities. Thus, instruction that capitalizes, and builds, on what students bring to a problem situation can motivate them to struggle with, and make sense of, the problem and share their thinking with classmates.* (NCTM, 1995, 2)

This philosophy which reflects the change in mathematics instruction in schools in the Western world has been preempted by a number of successful adult numeracy practitioners in Australia. When working with adults who had limited success in mathematics, and often very strong anxieties and dislike of mathematics, practitioners have directed instruction towards meaning-making at all levels, and particularly at relating mathematics to practical (but not necessarily simple) applications and interpretations. That is, numeracy.

Language and literacy research is informed by a number of overlapping, and sometimes competing, theories. These include emphases on linguistics, on

discourse, on language development and acquisition, and on differences between learning first and second languages, to name but some. So too, mathematics education research is informed by many theoretical orientations. These include constructivism, radical constructivism, critical theory, socio-cultural theories, cognitive psychological theories, cognitive science theories, and ethnomathematics theories. Debate in mathematics education is as alive and well as in language and literacy education. Each of these different theoretical perspectives is influencing work in adult numeracy.

The role of language in numeracy

The foregoing discussion of the present status of definitions of numeracy and its practice indicates that 'mathematics 'is seen to be embedded within numeracy, mathematics drawn from all aspects of mathematical knowledge and application. It bears little resemblance to 'the recognition of numbers and basic mathematical signs and symbols within text' (Australian Language and Literacy Policy, 1991, p.9). However, the interrelationships between language and numeracy, literacy and numeracy, and all of these and mathematics are seen as very significant. Most of our mathematical knowledge has been constructed through the medium of language, the discourse of the classroom and the home. Most communication about mathematical problems takes place through language, both oral and written, and including letters and symbols. Learners encounter most mathematical tasks through language, in either written or oral form. Learners from different cultural backgrounds may have developed different conceptual understandings of mathematical phenomena. The numerical script and word-naming systems used in different languages can affect learning, for example, in a Chinese language, '11' is symbolised and known as 'ten-one', a far more user-friendly notation than the English 'eleven'.

The relationship between language and literacy and mathematics has been a focus of considerable research. Ellerton and Clements (199?) undertook a substantive review of language factors in mathematical learning and of research that has been undertaken to explore these factors. The factors include:

- language and the construction of mathematical concept
- cultural environment
- the discourse of mathematics texts and classrooms
- bilingual education
- cognitive orientations including socio-cultural psychology

- psycholinguistic theory of language development and differences between 'natural' language and formal mathematical language
- the nature of problem-solving
- imagery.

It is apparent, therefore, that researchers and practitioners in mathematics and numeracy education are well aware of the significance of language in mathematics and numeracy learning. Language is not, however, seen as the overriding discipline within which numeracy is subsumed. This is best understood by examination of ways in which numeracy (or mathematics) learning differs from language and literacy.

Similarities and differences between language and literacy performance and numeracy

Numeracy is developed through procedures that reflect both first and second language learning. A degree of fluency in numeracy can be acquired through interaction with our socio-cultural environments, just as a degree of spoken language fluency is acquired. Similarly, critical awareness of the uses and interpretations of mathematics can be acquired through such interactions. However, to be able to use and utilise mathematical knowledge fluently, the mathematical code must be acquired. While there are many systems of mathematics around the world, modern technological development is strongly based on a common mathematico-technological base. Learning to use this knowledge base in appropriate ways is like learning the structures and conceptual configurations of a second language. Although most school mathematical curriculum have never been empirically validated, it is generally accepted that there is a gross logical order to the acquisition of formal mathematical knowledge.[4] While the English language system, say, revolves around a restricted set of letters and sounds, the mathematics system for a learner is boundless. The development of sophistication of language expression is more linear in comparison to the development of sophistication in mathematical usage, where both the sophistication of complexity of application and of repertoire base increase.

Similarly, although the construction of mathematics and numeracy has moved from the production of a correct answer or implementation of a singular correct sequence of steps, mathematical logic for some problem-solving processes is of a unique nature. For example, in studies of mathematical expertise, mathematicians confronted with a difficult mathematical equation to resolve have a process of separating the 'nasty' bits from others, thereby reducing the equation to something less daunting. This is then

resolved through a series of more familiar mathematically logical steps, often a different sequence by different experts, until satisfactory resolution is achieved. For non-experts confronting a simpler task, not only is the identification of which bits are more 'nasty' than others a mystery, but also the logical processes evade them.

Affective factors are significantly different for instruction and learning in numeracy in comparison with literacy and language. Adult literacy research and policy have documented thoroughly the apprehensions and embarrassment identified by adult literacy learners. In our society, to have severe literacy problems is a social embarrassment. However, in our society, to profess failure at mathematics or extreme dislike of anything mathematical, is not seen as embarrassing but almost as the norm. While we, as past mathematics teachers, must accept responsibility for the poor teaching and curriculum of mathematics in the past, the anxiety and hatred of mathematics felt by many students provide a challenge to all numeracy teachers as they try to facilitate the development of a numerate person. Every statement about the development of the self esteem and confidence of the adult literacy learner usually needs to be amplified exponentially[5] for the adult numeracy learner.

In first language education, spoken and aural development generally occurs first. As part of the development of literacy, the written code of a language is learned. Whole language approaches capitalise on already developed oral language skills in order to facilitate the writing process. Learners need also to acquire different genres of writing for different purposes and to understand the differences between oral and written language structures. Second language instruction for many years now has also emphasised the development of all four macroskills, reading, writing, listening and speaking. One debate, expressed previously and again here at a very simplistic level, occurs over the development of more functional orally-based and idiomatic language, the communicative competence approach, in comparison to more emphasis on the structures of the second language that occur in its written form.

In numeracy, it has only recently been realised that many adults also have well-developed oral mathematical skills. During the era of arithmetic and computational skills instruction in numeracy, instruction emulated the early grades of schooling — introduction to numbers, facts and algorithms in written forms. The evolution of numeracy began when instructors started involving more physical and orally-based instructional activities, coinciding with similar changes in mathematics education. Numeracy instructors therefore

have a dual role in developing the conceptual and strategic knowledge of adults at an oral level, and in assisting the transition to the expression of existing and expanded knowledge in mathematical ways.[6] Again, it is the written code of mathematics that is a barrier to many learners.

A final point of comparison between numeracy, and language and literacy, relates to research being undertaken examining how mathematics is constructed or used in different contexts for school, personal and work purposes and in different cultures. Some of the most quoted work examines the mathematical practices of adults and children in North Africa and South America. Reinforcing the above notion of oral versus written performance, it has been found the street children in Brazil who sell goods on the streets have remarkable computational facility. They do not reproduce this facility in written performance. It is always difficult to translate this research into application for a culture such as Australia, however, it clearly indicates that both children and adults can develop mathematical knowledge through non-formal education. The quest for Australian adult numeracy education is to recognise and develop processes to capitalise on such knowledge for the learner's own advancement. There is also a major warning that assessment in numeracy that relies on traditional formats may be misleading.

Research investigating how mathematics is used at work has more direct application to adult numeracy. Most studies have shown that adults solve practical mathematical applications in ways that are different from the algorithmic procedures taught in school. For example, Scribner and Stevens (1989) examined procedures used by shift workers in a dairy factory to fill orders for goods of different sizes packed in cases which hence held different quantities. That is, the same size case may hold 24 yoghurt or 12 milk or 15 cream. An order might ask for 6 yoghurt, 8 milk and 2 cream. Scribner and Stevens noted that :

> *During the work shift, the number of full, empty, and partially full cases available for filling orders changes. Experienced product assemblers take advantage of these changing conditions to fill orders in such a way that involves the least physical effort. On some occasions assemblers fill* ***plus*** *orders by taking that specified number of units to an empty case and* ***minus*** *orders by removing the specified number of units from a full case. Their operations - adding or taking away - are isomorphic to the symbolic expression of the order... On other occasions they use partially full cases available to assemble the order with fewer moves than the literal solution involves. ... solutions require some additional mental manipulation of the numerical*

information in the order so that it can be mapped onto quantitative properties of different physical arrays.

This text, while perhaps not very approachable for non-mathematicians, indicates that the workers were operating with numbers in different ways from the formal algorithms and base of ten taught in basic or school arithmetic. Their logical manipulations of numbers were complex and multiple simultaneously.

While the National Framework for Adult English Language, Literacy and Numeracy indicates that language, literacy and numeracy are produced differently for different contexts and purposes, adult numeracy faces a bigger challenge in determining the appropriate directions for instruction for adults in specific vocational studies. In language and literacy, students may practise report writing and minute taking, reading notices and safety signs. In numeracy, how far do we diverge from the traditional domains of mathematical performance to develop the specific logics of different workplaces?

Overview of current research in adult numeracy and related fields

The purpose of this paper is to provide the context for consideration of adult numeracy research as well as to provide indications of strategic approaches to future adult numeracy research planning. To develop this context it has been necessary to explicate the present status of adult numeracy, in the expectation that knowledge about this status has not yet been widely disseminated beyond the adult numeracy field. In conjunction with this, changing emphases in mathematics education in general, the role of language in mathematics and numeracy, and similarities between language, literacy and numeracy development and instruction have been considered. One of the major aims of these discussions has been to demonstrate how broad the area of adult numeracy has become, to show that this is now a critical time in its development and to justify that the field of adult numeracy now requires individual attention through policy and research in its own right.

The field of school and higher education mathematics learning and education has a substantial research base. Adult numeracy practitioners and researchers have often had to draw on the outcomes of child-based research to address their own problems. The following discussion explores the general status of adult numeracy research, particularly adult numeracy in the context of adult basic education and workplace education, and the implications for future research in adult numeracy in Australia. At this point it should be noted that although the international research base for adult

numeracy is small, the research and practice of the Australian adult numeracy community are at the forefront and well-placed to influence international developments.

The nature of adult numeracy

While a number of writers are now discussing the nature of adult numeracy, drawing on both the developments in literacy theory and practice and in mathematics education, implications of new definitions for different contexts have not yet been explored. More widespread dissemination and discussion of numeracy are also needed.

Further research is needed at the macro level considering the nature of numeracy, what it is to be numerate, the nature of mathematics and the relationship between numeracy and mathematics.

The role of language in numeracy and mathematics

As noted previously, the research base on the variety of roles that language plays in numeracy and mathematics for school age, and higher education to some extent, is considerable. However, little research has been undertaken with adult numeracy students. It should not be assumed that the language factors for adults, who have a greater range of experiences, more fully developed oral language skills but possible less formal mathematical training, will be the same as for children. For example, vocational mathematical training may require immediate understanding of sophisticated work terms whereas children are more likely to be being introduced to vocabulary and terms that match their levels of social and language experience. Language factors in numeracy and mathematics need to be investigated at macro, meso and micro levels, from the discourse of the classroom as it affects and facilitates numeracy development, to the acquisition and understanding of such vocabulary or mathematical tasks.

The role of mathematics in language

While there has been considerable research in the mainstream mathematics education field about the role of language in mathematics, the reverse is not the case. Quantitative literacy, as defined through international and national studies, explores the interpretation of text in which mathematics is embedded, such as reading medicine dosages. It also incorporates simple computations such as bill totals and change. Information is available about the levels of proficiency of the population on such tasks. However, some research

has also focused on comprehension of text in which less overt mathematics is embedded. Newspapers are an example of documents that rely on a considerable amount of mathematical prior knowledge that is often not expressed in mathematical symbols, for example, understanding of rate in a discussion of birth or death rates. Such prior knowledge may also be culturally specific.

Thus there is considerable scope for research to be undertaken with materials and contexts, oral, written and visual, commonly encountered by adults in personal, work and education activities, that examines the effect of mathematical content on comprehension. This research can encompass the relationship between literacy and numeracy and should specifically include English both as first and second language.

The needs of specific groups in numeracy education

Ethnomathematicians provide substantial evidence of the communalities and differences in mathematical structures, concepts and language between cultures. Adult numeracy practitioners are to an extent aware of both the differences in mathematical experiences students bring from different cultures and the cultural biases some mathematical instruction can induce. Most of the research to date has been undertaken with groups who are living in specific and often isolated cultures, such as indigenous Australians in rural settings. More systematic research is needed looking at the cultural mathematical experiences of all adult numeracy students and the interactions between numeracy instruction and cultural identity. Broadening this area, research is needed investigating any systematic effects such as socio-cultural influences on adult numeracy including gender and cultural background. For example do female adult numeracy students in general differ from male adult numeracy students? Who seeks adult numeracy assistance more? Who may need adult numeracy assistance more? Is the nature of the instruction needed different for different groups? Research in primary and secondary schools indicate that girls do not achieve at a lower level than boys in mathematics but that they do undertake higher mathematics in the upper years of schooling at a substantially lower rate than do boys. Therefore the depth of mathematical experience of most women may be less than men. Should adult numeracy providers examine ways to attract more women into numeracy classes?

Equally, the expectations and needs of specific disability groups in adult numeracy classes need to be researched. These groups include specific physical disabilities such as deafness or visual impairment, adults with

severe learning disabilities whose only recourse to education is through adult basic education classes, and individuals who have undergone trauma affecting cognitive performance such as major illness or accident.

Adult numeracy practices

A growing body of research has developed regarding the numeracy activities of adults in and out of the workplace. The focus of this research has been to identify the numerical demands for 'functional' life and work skills or to identify the non-standard ways in which adults approach numeracy activities in practice. Adult numeracy practitioners are also aware of the differences adults may have in capacity to be numerate orally versus a written format. The research to date however is again very specifically situated. More research is needed to investigate the adult numeracy practices of adults and of adult numeracy students as a whole or to add to the present extent of knowledge. No database is available to indicate the types of activities and mathematical strategies used by adult numeracy students outside of the adult numeracy classroom.

Adult numeracy needs

Just as there is limited information about adult numeracy practices, there has been no systematic research into adult numeracy needs. How are adult numeracy needs and expectations defined by the various stakeholders, including employers[7], practitioners and adult numeracy students themselves? What type of adult numeracy provision is best for what contexts, what type of mathematics is relevant in what contexts, how should formal mathematics, life and work applications, and critical understanding and interpretation be incorporated? Most importantly, how can adult numeracy provision make most effective use of what the numeracy adults have already developed?

Critical numeracy

Critical numeracy is seen by the adult numeracy field to be as significant as critical literacy by the adult literacy field. Even when adults may claim to limited numeracy needs and activities in their own lives, their interactions with society are being strongly influenced by numeracy. There is scope for research that focuses not on the understanding of the mathematics of numeracy but on how adults are reading the numeracy world around them.

Adult learning and adult numeracy

Research in general education has established strong links between the affective domain and performance. Motivation, positive attitude towards learning and self-esteem have been found to be significant factors in learning success. In many discipline areas, metacognitive skills have been found to be important in learning, none more so than in mathematics. Research is needed to see how these factors are related to learning in adult numeracy. What metacognitive attributes do adult numeracy students have? Do they use metacognitive or organisational skills in other areas that can be transferred to adult numeracy practice?

It has already been stated that many adults have very negative attitudes to mathematics. Is this true of all contexts, what effect does any such attitude have on numeracy learning and how best can it be turned around? In the past most discussion of adult learning principles are based on andragogical theories that posit the adult learner as self-directed, intrinsically-motivated and goal-directed (Knowles, 1984). In a context where many adult learners are in workplace or labour market programs on a less than voluntary basis, and in the area of mathematics, these assumptions cannot be made. What then are the affective characteristics of adult numeracy students?

Effective instruction in adult numeracy

Many of the research questions posed already have touched upon the need for effective instruction. Little is known about the resource base for adult numeracy teachers in Australia. Many adult literacy teachers are uncomfortable teaching numeracy. Who is presently teaching adult numeracy in Australia, what is their background, who should be teaching adult numeracy? What training is necessary? Do the best adult numeracy teachers have mathematics, literacy of specialist backgrounds or are other characteristics more salient?

The role of computer-assisted or flexible-delivery instruction in adult numeracy needs to be investigated. Many adult literacy learners and tutors operate in isolation throughout Australia, the need for adult numeracy learning in isolated areas may be greater. Anecdotal evidence to date is that effective adult numeracy teachers can develop renewed processes of mathematical thinking and positive attitudes with adult numeracy students. Ineffective adult numeracy teachers unfortunately reinforce the status of the adult numeracy student. If there is a limited resource base of adult numeracy teachers available, interactive computer instruction may be desirable.

Certainly there is a need for more research looking at adult learners' attitudes to computer instruction and effective software. At present numeracy software is extremely limited in focus.

Assessment and reporting in adult numeracy

Research on assessment in literacy and numeracy records the shift from simplistic measurements on isolated tasks to complex performance-based assessment approaches and the issues they introduce. The National Reporting System (1995) has introduced a framework whereby good practice in adult literacy and numeracy curriculum and reporting is modelled. It is to be hoped that there is some 'backwash' effect from the National Reporting System, particularly in the numeracy area, on the assessment approaches and practices of practitioners, as well as on the expectations of funding bodies and policy makers. Research is needed in all areas of assessment and reporting in adult numeracy. The dramatic changes that are occurring in mathematics education have not yet had an impact on the adult numeracy sector in general. At the same time, the introduction of competency-based assessment in accredited TAFE curricula may lead to conflict between good assessment practices in numeracy and outcome-based assessment. In mathematics education the development of strategic mathematical processes and problem-solving ability are seen to be important goals. The reliance on simplistically-expressed competencies has been found to be at the cost of the development of higher order processing (Wolf, 1995). Research is needed therefore on current assessment practices in adult numeracy, on teacher knowledge in assessment in adult numeracy and on effective strategies for assessment in adult numeracy.

Policy initiatives and provision effects on adult numeracy provision

A review of the current status of research, and areas where research needs to be undertaken can be infinite. The consideration so far has highlighted a number of areas within adult numeracy instruction and learning that are regarded as important to the development of effective and comprehensive adult numeracy provision in Australia. External and policy factors also have an impact upon adult numeracy provision in Australia, and research into these is also desirable. At present there is no clearly defined statement or policy about adult numeracy provision, client demand and expectations for adult numeracy. Such basic information is desirable for forward planning. The 1996 Survey of Aspects of Literacy by the Australian Bureau of Statistics will identify adult performance on a restricted range of numeracy (computational) and mathematical literacy tasks. This will provide a basis

at least for examination of the extent of adult numeracy demand. The results for the quantitative literacy dimension in the original national study (Wickert, 1989) indicated that need for provision in this area was approximately double that on the other dimensions.

Initiatives such as WELL funding, the National Framework for Adult English Language, Literacy and Numeracy Competency and the National Reporting System, to be implemented in funded programs by 1997, all have an impact on the extent and nature of adult literacy and numeracy provision. It will be important to undertake research examining the effects of these initiatives on adult numeracy provision.

Congruent with the above statements, there is no data base available about the present extent of adult numeracy provision in Australia, the allocation of funds and other resources to this area, nor an approximate (and reliable) estimate of the number of students in specific and integrated programs.

RECOMMENDATIONS:

Strategic planning for research in adult numeracy

Adult numeracy is a complex area worthy of individual recognition. It has strong connections with current trends in mathematics, literacy and language education. It is, however, an area where so much research of a basic and applied nature for adults needs to be undertaken, the potential is unlimited. The previous discussion has tried to summarise where research has already been undertaken and where research, particularly examining the 'adult' in adult numeracy is needed. Clearly it is impossible to address all of these different needs and directions simultaneously. Therefore, **it is recommended that a research strategy should be formulated to incorporate three strands**. Further, **it is recommended that some research initiatives should be instigated in each of these areas in the immediate future**, with the long term goal to build a comprehensive research profile within each dimension.

Strand 1. Policy

Research and provision in adult numeracy cannot be adequately addressed until there is first a national policy statement on adult numeracy and strategic implementation.

A research project should be commissioned to provide the framework for the development of a national policy statement on adult numeracy. The project report should incorporate a substantial companion document to justify a policy statement. This will include a full and comprehensive review of past and present conceptualisations of numeracy, nature of provision in Australia and overseas, and the current status of research findings particularly with respect to adults.

The policy statement should incorporate national goals for adult numeracy and a projected implementation plan for provision, staff development and dissemination of information in the wider community.

Strand 2. Provision

Information about the nature of provision in adult numeracy in Australia needs to be collected. A research project should be commissioned to:

- provide demographic information that is as reliable as possible about the extent of provision and funding for adult numeracy at present[8]
- identify the extent of provision needed for adult numeracy in Australia in community, further and vocational education contexts, including issues of access and resources
- examine the impact of program decisions such as the National Framework of Adult English Language, Literacy and Numeracy and the National Reporting System on adult numeracy.

Strand 3. Pedagogical

The directions for research into effective practice for adult numeracy learners are abounding. The basic question to be posed is

> *How do we enhance adult numeracy learning, trying to connect ideas of 'good practice' with theoretical frameworks, and to build up a useful basis for understanding adult numeracy and learning?*

It is recommended that a consortium of action learning research projects be instigated throughout Australia to be coordinated through tender. Three procedures should be used to maximise the usefulness of these projects for Australia (and the international community) as a whole.

1. There should be a mechanism for collating and reporting the aims, processes and outcomes of the projects such as publication in a practitioner-friendly book or series of booklets, or through videos, workshop and other means of dissemination.

2. In conjunction with the action learning projects, a national conference should be held in Australia, with some financial assistance available for practitioner participation from all states.

3. A thematic approach should be used, again to maximise the utility of a number of small research studies being undertaken in situ. A number of themes arise readily from the previous considerations:

    - the numeracy practices of the adult numeracy learner
    - the relationship between numeracy in personal, community, work and training activities
    - effective instructional practices in adult numeracy (including flexible delivery)
    - the expectations for adult numeracy by various stakeholders
    - good practice in assessment and reporting in adult numeracy
    - the relationship between the affective domain and learning by adult numeracy students
    - adult numeracy needs for special groups of learners.

    One or two themes should be selected on a yearly basis so that a critical mass of research can be undertaken in an area.

Endnote

Adult numeracy in Australia is at an exciting time. The enactment of these recommendations would ensure that numeracy, too, would no longer the Cinderella of adult education.

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notes

1. The extent of funding for adult numeracy programs through WELL funding is far less than for language and literacy, partly it is recognised because of the focus of applications but also because many people may not recognise that WELL funding would include numeracy.

2. From here on, numeracy is referred to as a separate identity from literacy and literacy is used as a term that does not incorporate numeracy in a generic sense.

3. This brief summary is clearly going to be inadequate in addressing the range of literacy and language research and is not intended to be comprehensive. Consider the frustration numeracy practitioners and researchers have similarly felt about limited references to numeracy.

4. The finely-detailed sequences of most schooling are however being challenged. In adult numeracy practice (and in schools), for example, it is often found that when using a problem-based approach, students develop conceptual understanding of, and can work with, what in school terms are regarded as 'difficult' concepts while not having all of the mathematical knowledge previously deemed to be prerequisite. However, while a student can have a conceptual understanding of an average, say, and be able to obtain such a statistic through a variety of means, they will also need to have knowledge of the number system in order to be able to express such a statistic in a commonly understood form.

5. It is interesting to consider how mathematical terms have enriched our language and are accepted as common parlance.

6. In all sectors of mathematics education, from primary through to higher education, the notion of what is an acceptable way to express mathematical ideas and solutions has changed. In many systems, students are required to provide explanation in text form as well as in symbolic form, and to justify orally or in writing their solution. This direction is clearly intended to enhance mathematical understanding and appropriate use. It is interesting to note, however, that this change in direction is already causing concern as to whether in fact it introduces a new disadvantage for those with limited language facility such as cultural minority groups (Baker & O'Neil, 1994).

7. While there have been some surveys in the past whereby employers are asked to indicate the mathematics their workers need and use, these data are highly unreliable. Most employers are unaware of the numeracy demands of occupations within their business and usually underestimate the extent of numeracy practices required by workers. As with many of these areas of research need, intensive observational and interview data collections are needed rather than superficial surveys.

8. The difficulty of identifying provision and funding that may be integrated with literacy and language and within vocational training is acknowledged. However, there is a general belief among adult numeracy practitioners that the extent of funding directed to numeracy training is far less than for other areas. There is also concern that numeracy provision is receiving token mention but little enactment.

ADULT NUMERACY POLICY AND RESEARCH IN AUSTRALIA: the present context and future directions

prepared for the National Research Strategy in Adult Language, Literacy and Numeracy Project by Dr Joy Cumming

Adult numeracy in Australia is at an exciting time. This discussion paper describes the present context for adult English language, literacy and numeracy policy and provision and presents an overview of current research in adult numeracy and related fields.

It looks at the role of mathematics in language, the needs of specific groups in numeracy education, critical numeracy, assessment and reporting in adult numeracy, and the effects of policy initiatives on adult numeracy provision. The paper concludes by making recommendations for strategic planning of research in adult numeracy.